Child Street
16 State House Station
Augusta, Maine 04333

Maine Department of Transportation

Transportation Research Division

Technical Report 92-34

Field Trial of Gravel Stabilization Methods
Route 1, Cyr - Van Buren, Maine

Seventh Interim Report, June 2003

Transportation Research Division

Field Trial of Gravel Stabilization Methods

Route 1, Cyr - Van Buren, Maine

Introduction

This experimental construction project was developed, designed, and inspected by personnel from the University of Maine, Civil Engineering Staff. The project was constructed on and as a part of Project Number 2586.00 in Cyr Plantation - Van Buren (see Figure 1).

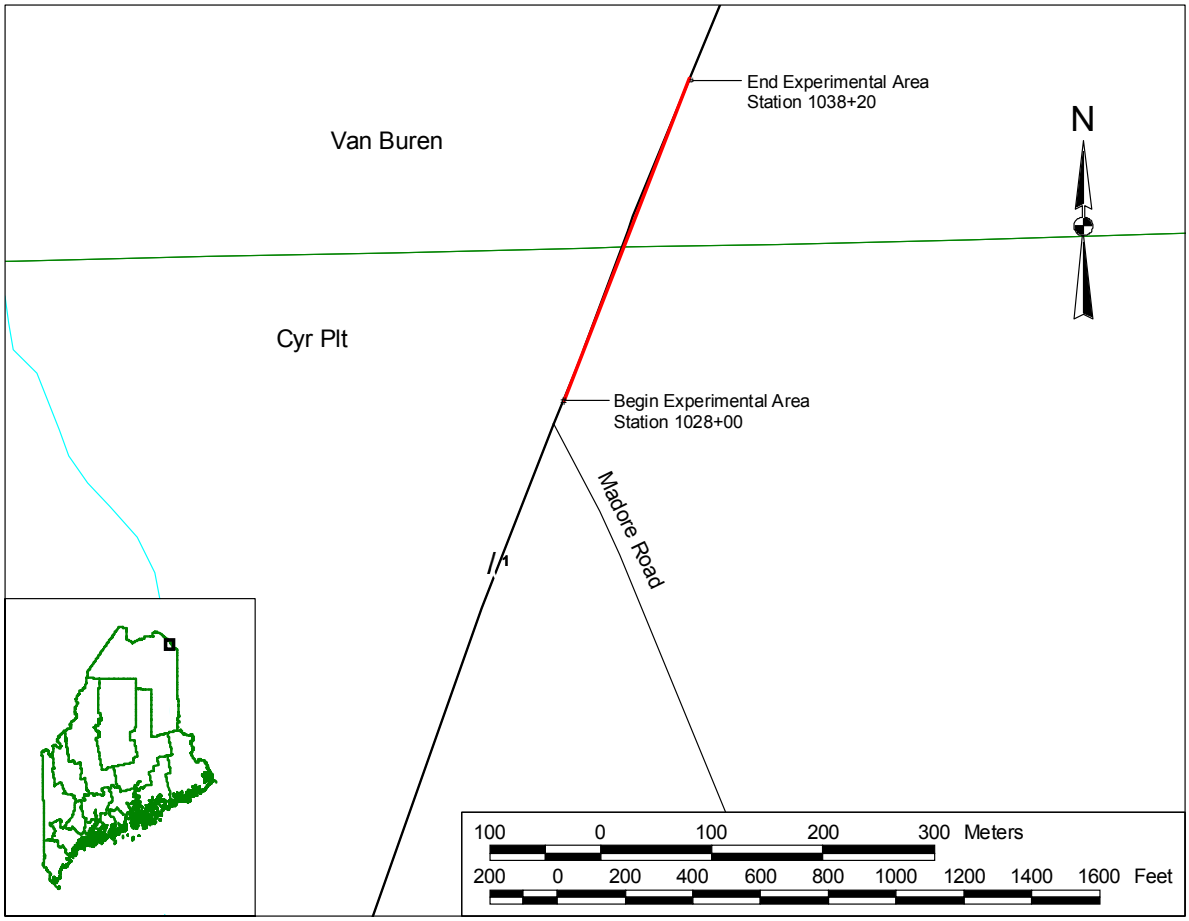

Figure 1. Project Location Map

This was a complete reconstruction project 2.2 miles in length. The experimental section contains 6 experimental base types and is 1020 feet in length. The experimental section began at Station 1028+00 and ended at Station 1038+20. The test section consisted of 200 foot segments of soil cement, asphalt, calcium chloride, modified, standard and one 20 foot untreated section. The stabilized and control sections were located as follows:

Soil Cement Stabilized	Station 1028+00 to 1030+00
Modified Subbase Control	Station 1030+00 to 1032+00
Asphalt Stabilized	Station 1032+00 to 1034+00
Untreated Section	Station 1034+00 to 1034+20
Calcium Chloride Stabilized	Station 1034+20 to 1036+20
Standard Subbase Control	Station 1036+20 to 1038+20

The Soil Cement Stabilized section is a mixture of Modified Subbase (mentioned later) and 6 percent by weight of Type I Portland Cement.

The Modified Subbase Control section is standard subbase aggregate MDOT specification 703.06b Type D with a 2 inch maximum aggregate size. This aggregate was used on all stabilized sections to facilitate blending of each treatment.

The Asphalt Stabilized section is a mixture of Modified Subbase and 4.5 percent of MS-4 Emulsified Asphalt.

The Untreated section consists of Modified Subbase.

The Calcium Chloride Stabilized section is a mixture of Modified Subbase and 0.75 gal/yd^2 of 35 percent liquid calcium chloride solution.

The Standard Subbase Control section consists of standard subbase aggregate MDOT specification 703.06b Type D with a 6 inch maximum aggregate size.

Construction on this project started in September 1990 and was completed in the summer of 1991. A background of the stabilization agents, their uses, advantages and disadvantages is explained in the MDOT construction report titled “Field Trial of Gravel Stabilization Methods”, Experimental Construction Report 92-34, printed December 1991. This report also provided preliminary design results as well as test results obtained during construction. In addition to the test results, a plan for long term monitoring was also included in Appendix G and reproduced for this report in Table 1. Some of the features to be monitored are rutting and serviceability, such as roughness and overall performance. Strength measurements using pavement deflection was also suggested. Most of the evaluations can be performed with the Automatic Road Analyzer (ARAN) and Falling Weight Deflectometer (FWD) test vehicles. Long term monitoring of the calcium chloride is specifically mentioned. For this phase they recommend boring test holes and sampling the base every 5th year to monitor the possibility of leaching calcium chloride.

Project Evaluation

This report covers the period of time from January 2000 thru December 2001.

Table 1 contains a Testing Schedule for the project. The table has been updated as a result of recommendations in the 5th Interim Report. Calcium Chloride was not recommended as a stabilizing agent due to low structural readings and the high incidence of pavement distress. As a result, $CaCl^2$ Leaching tests have been discontinued. Cross Section and Profile Elevation measurements exhibited little change in six years and have also been discontinued. According to the revised Test Schedule, roughness, rut depths, pavement deflections and crack survey data were obtained for this report.

Table 1
Testing Schedule for Cyr – Van Buren
Field Trial of Gravel Stabilization Methods

Year	ARAN Ride (IRI)	ARAN Rut Depth	Pavement Deflection	Elevation X-Sections	Elevation Profile	Crack Survey	$CaCl_2$ Leaching
1991	*	*	*				
1992	*	*	*	*	*	*	
1993	*	*	*	*	*	*	
1994	*	*	*				
1995	*	*	*	*	*	*	*
1996	*	*	*				
1997	*	*	*	*	*	*	
1998						*	
1999	*	*	*			*	
2000						*	
2001	*	*	*			*	
2002						*	
2003	*	*	*			*	
2004						*	
2005	*	*	*			*	
2006						*	

Ride Summary

The ARAN test vehicle was replaced in 1998 with an updated ARAN. The new ARAN was used to measure roughness; this is an ASTM Class II profiler using lasers to measure the vehicle's height above the road surface and accelerometers to measure vertical forces caused by surface deformities. Measurements are recorded every two inches in each wheel path. Data was collected on October 30, 2001 and results are graphically presented in Figure 2 using International Roughness Index (IRI) values.

Roughness values have increased in the Soil Cement, Calcium Chloride, and Modified Subbase sections and decreased in the remaining sections. The Standard Subbase section continues to outperform the other sections with an IRI of 65.04 in/mi. The Asphalt Stabilized, Calcium Chloride, and Soil Cement sections are 42%, 40% and 51% rougher than the Standard section with IRI numbers of 92.67, 98.79, and 91.26 in/mi respectively. The Modified Subbase section has the highest IRI at 107.59 in/mi.

Appendix A compares IRI data for each section using Tukey's Studentized Range (HSD) Test. Results indicate a significant difference between the Modified and Standard Subbase sections only.

After ten years of traffic, IRI values for all sections are still within the smooth rating of 0-190 in/mi.

Rut Depth Summary

The ARAN test vehicle was also utilized to measure rut depths. The ARAN calculates rut depths in real time using ultrasonic sensors spaced 4 inches apart on a bar that traverses the width of the travel lane. Rut depths are collected by measuring the distance between the bar and road surface creating a transverse profile of the roadway at 50 foot intervals. Figure 3 contains a graphical display of the test results.

Average rut depths have increased 33% in the Modified Subbase section and 21% in the Calcium Chloride section as compared to last years measurements. The remaining sections increased or decreased slightly over the same period.

The Modified Subbase section appears to be rutting at a quicker rate than the remaining sections.

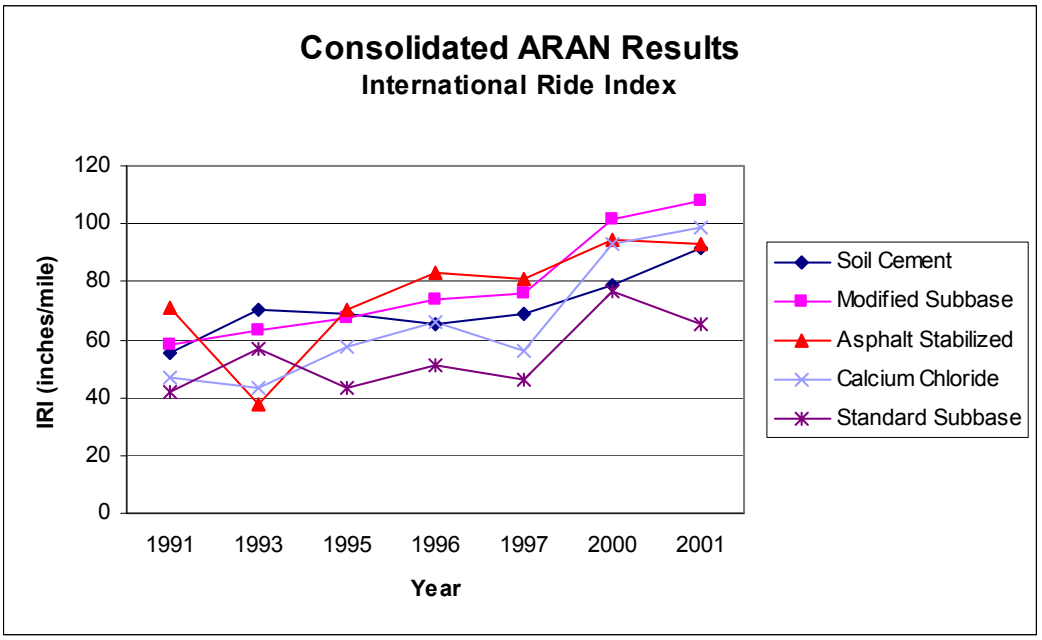

Figure 2. Ride Summary

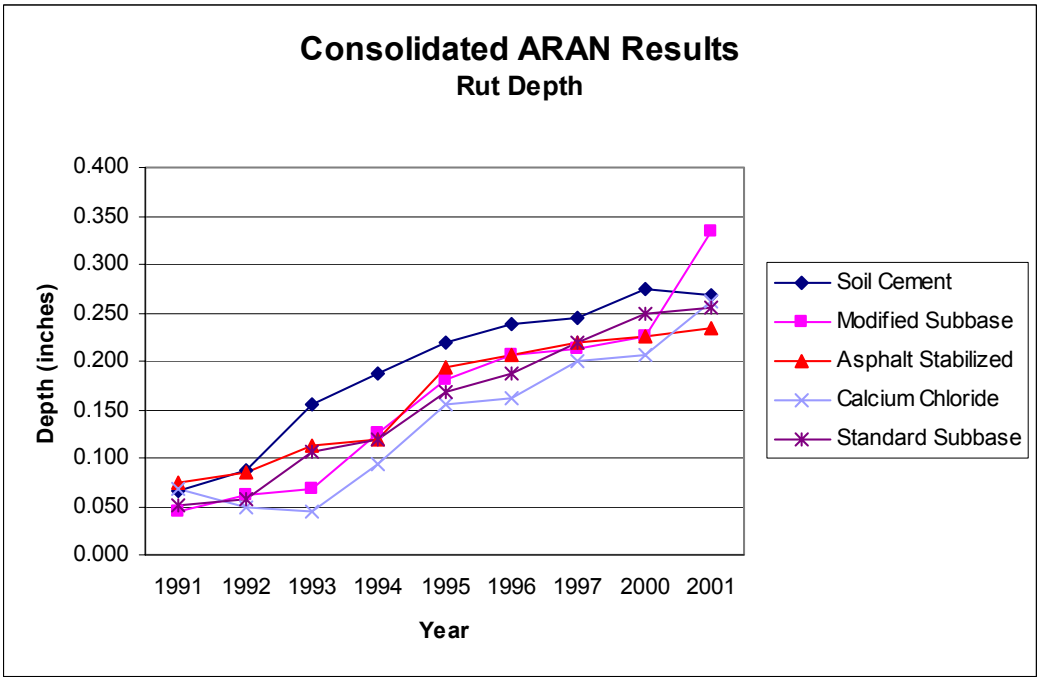

Figure 3. Rut Depth Summary

Appendix B compares Rut data for each section using Tukey's Studentized Range (HSD) Test. Analysis reveals no significant difference between sections.

All sections have very little rutting over ten years with the greatest average rut depth of 0.334 inch and a minimum average rut depth of 0.233 inch.

Pavement Deflection Summary

Structural conditions were measured using two different test vehicles, the Road Rater and the FWD.

The Road Rater was used from 1991 to 1996. This test vehicle has five sensors that measure pavement deflections as a weight vibrates the pavement at a specific frequency. The results are displayed in Figure 4 as an overlay required. This is the depth of overlay necessary to restore each section to a 20 year design life using 24 inches of subbase and 6 inches of bituminous pavement, the lower the number the stronger the section. All readings are negative suggesting no overlay is necessary.

For this time period the Calcium Chloride, Modified Subbase, and Standard Subbase sections were structurally similar. The Asphalt Stabilized section has improved stability and the Soil Cement section has the greatest stability.

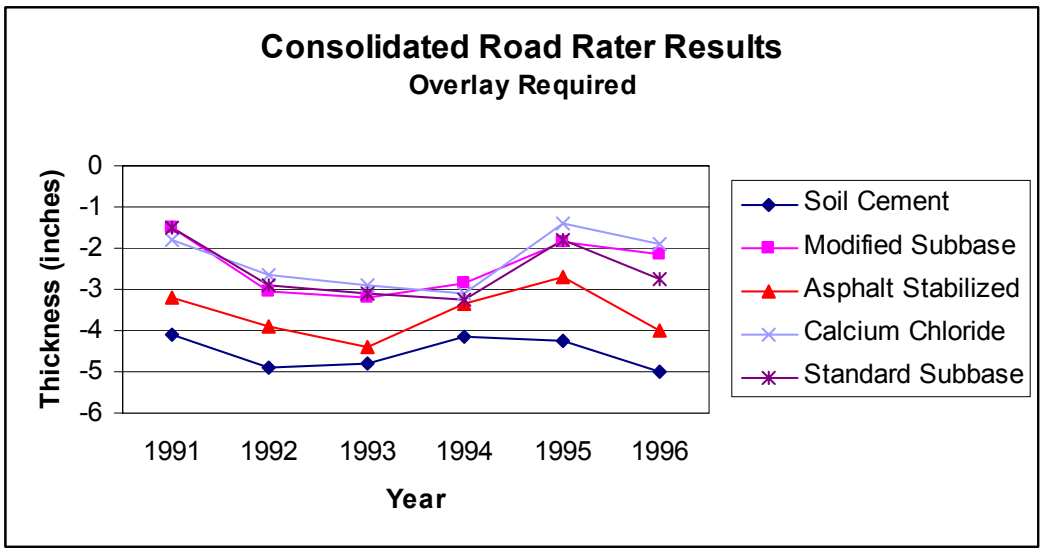

Figure 4. Road Rater Summary

The FWD also measures pavement deflections. This unit drops a weight onto a platform that is resting on the pavement, creating deflections that are recorded by seven sensors extending away from the platform. Pavement deflections indicate the structural stability of the roadway to a depth of 5 feet. FWD results are displayed in Figure 5 as an effective existing pavement structural number (SNeff) for 24 inches of subbase and 6 inches of bituminous pavement combined, the higher the number the stronger the section. Similar roadways of this design have structural numbers between 5 and 6.

The Calcium Chloride, Modified and Standard Subbase sections continue to be structurally equal. The Asphalt Stabilized section has greater stability than the previously mentioned sections and has increased structurally since 1995. The Soil Cement section continues to outperform the remaining sections but has weakened since 1997.

A statistical analysis of FWD data is presented in Appendix C. Data reveals a significant difference when comparing Asphalt and Soil Cement stabilized sections to the Modified, Calcium Chloride, and Standard Subbase sections.

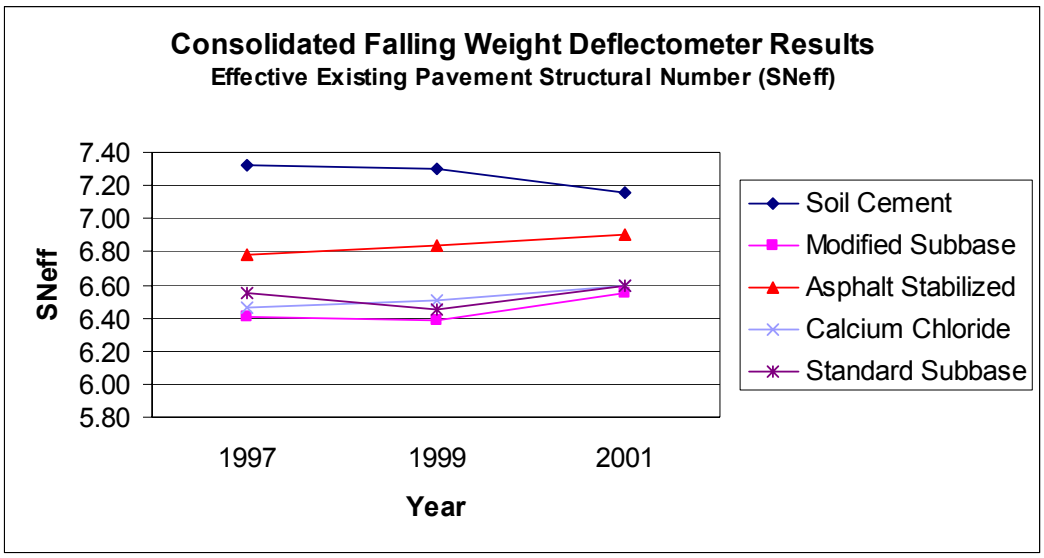

Figure 5. Falling Weight Deflectometer Summary

Crack Survey Summary

A visual inspection of the project was conducted on August 1, 2001. Cracking has increased slightly since the last inspection in 1999. All cracks have been sealed with a rubber sealant.

There are no additional areas of flushing asphalt but the amount of asphalt flushing from the Asphalt Stabilized section has increased in severity. Photo 1 contains a 45 foot long area of asphalt flushing to the surface between station 1032+00 and 1033+00. The asphalt has pooled at centerline on the inner wheelpath and is flowing to the shoulder in the outer wheelpath. Asphalt in this area is 0.5 inch thick in spots with tire tread imprints as depicted in Photo 2. Flushing is not isolated to the Asphalt Stabilized section only. The Soil Cement, Modified Subbase, and Standard Subbase sections have areas of flushing 1 to10 feet in length that are less severe. The Calcium Chloride section has no flushed asphalt areas. It is not known if stabilizing the base with asphalt is contributing to the amount of flushing. Subsurface exploration may determine if this is caused by the hot mix asphalt or the treated subbase or a combination of both.

The Modified Subbase, Asphalt Stabilized and Calcium Chloride stabilized sections have full length centerline joint separation. The Soil Cement section has 92 feet of centerline separation and the Standard Subbase section has a total of 170 feet of centerline cracking.

All sections have shoulder joint separation. The Soil Cement section has increased from 110 feet to 175 feet. The Modified Subbase, Asphalt Stabilized, Calcium Chloride, and Standard Subbase sections have no additional shoulder joint separation and remain at 182 feet, 280 feet, 153 feet, and 192 feet respectively.

The Modified Subbase and Calcium Chloride sections each have one full width transverse crack. The Soil Cement section has two full width transverse cracks plus two 4 foot cracks across centerline at station 1028+80 and 1029+12. The Asphalt Stabilized area has three transverse cracks; one full width, one three quarters across the lane, and a half width crack in the southbound lane. Transverse cracks have increased in the Standard Subbase section from one full and one three quarters crack to two full width cracks and a 4 foot crack at station 1037+40.

The Calcium Chloride section has an additional 20 feet of longitudinal cracking between wheel paths bringing the total to 160 feet and the Soil Cement section has 5 feet of cracking between wheelpaths. No other sections are experiencing cracking of this type.

Load associated cracking has not occurred within the experimental project.

Photo 1. Flushing Asphalt

Photo 2. Tire Tread Imprint

Conclusion

Structurally, the Soil Cement and Asphalt Stabilized sections continue to outperform all other sections. Although pavement cracking is high for these sections, both treatments are supporting the roadway better than the remaining treatments.

Based on the depth of rutting, rough ride, and high deflections as compared to the remaining sections, the Modified Subbase section is not performing well and is not recommended as a viable subbase material.

The Calcium Chloride section is performing very similarly to the Modified section and is not recommended as a stabilizing agent.

The Standard Subbase section is performing slightly better than the Modified Subbase and Calcium Chloride sections but has a history of poor degradation values hence the reason for this experimental project.

The next Interim Report will cover the period from January 2002 to December 2003. Additional tests to determine the cause of asphalt flushing will be included.

Prepared by:

Brian Marquis
Transportation Planning Specialist

Reviewed By:

Dale Peabody
Transportation Research Division Engineer

Additional Available Documents:

Field Trial of Gravel Stabilization Methods, Construction Report # 92-34, December 1991
First Interim Report, May 1993
Second Interim Report, February 1995
Third Interim Report, January 1996
Fourth Interim Report, January 1997
Fifth Interim Report, May 1998
Sixth Interim Report, September 2000

For more information contact:

Brian Marquis
Maine Department of Transportation
P.O. Box 1208
Bangor, Maine 04402 - 1208
Phone: 207-941-4067
E-mail: brian.marquis@maine.gov

APPENDIX A
STATISTICAL ANALYSIS of IRI MEASUREMENTS
The SAS System
The GLM Procedure

Class Level Information

Class	Levels	Values
group	5	Asphalt_, Calcium_, Modified, Soil_Cem, Standard

2001 IRI data

Section	IRI
Soil_Cement	72.99, 69.54, 79.43, 104.31, 109.33, 127.95, 76.25, 90.27
Modified_Subbase	84.68, 60.6, 157.36, 91.45, 84.98, 177.05, 115.23, 89.39
Standard_Subbase	59.33, 46.37, 52.48, 62.41, 109.88, 57.13, 67.7
Calcium_Chloride	117.33, 48.84, 76.83 , 98.59, 119.49, 131.64
Asphalt_Stabilized	91.76, 94.01, 89.88, 78.11, 94.56, 107.68
Number of observations	35

Tukey's Studentized Range (HSD) Test for TESTs
NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05	Error Mean Square	737.2257
Error Degrees of Freedom	30	Critical Value of Studentized Range	4.10208

Comparisons significant at the 0.05 level are indicated by ***.

group Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
Modified - Calcium_	8.81	-33.73	51.34	
Modified - Asphalt_	14.93	-27.61	57.46	
Modified - Soil_Cem	16.33	-23.04	55.71	
Modified - Standard	42.55	1.79	83.31	***
Calcium_ - Asphalt_	6.12	-39.35	51.59	
Calcium_ - Soil_Cem	7.53	-35.01	50.06	
Calcium_ - Standard	33.74	-10.07	77.56	
Asphalt_ - Soil_Cem	1.41	-41.13	43.94	
Asphalt_ - Standard	27.62	-16.19	71.44	
Soil_Cem - Standard	26.22	-14.54	66.98	

APPENDIX B
STATISTICAL ANALYSIS of RUT MEASUREMENTS
The SAS System
The GLM Procedure

Class Level Information

Class	Levels	Values
group	5	Asphalt_, Calcium_, Modified, Soil_Cem, Standard

2001 Rut Depth Data

Section	Rut Depth
Soil_Cement	0.39, 0.16, 0.35, 0.2, 0.51, 0.2, 0.35, 0.16, 0.39, 0.16, 0.24, 0.2, 0.28, 0.2, 0.31, 0.2
Modified_Subbase	0.24, 0.16, 0.2, 0.28, 0.47, 0.2, 0.28, 0.24, 0.43, 0.16, 0.24, 0.28, 0.47, 0.08, 0.63, 0.98
Asphalt_Stabilized	0.67, 0.12, 0.2, 0.16, 0.35, 0.12, 0.12, 0.12, 0.39, 0.24, 0.24, 0.12, 0.31, 0.16, 0.24, 0.16
Calcium_Chloride	0.35, 0.12, 0.28, 0.63, 0.31, 0.16, 0.2, 0.12, 0.24, 0.2, 0.28, 0.24
Standard_Subbase	0.31, 0.2, 0.28, 0.16, 0.35, 0.2, 0.35, 0.24, 0.31, 0.16, 0.35, 0.16
Number of observations	72

Tukey's Studentized Range (HSD) Test for TESTs
NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05	Error Mean Square	0.022371
Error Degrees of Freedom	67	Critical Value of Studentized Range	3.96468

Comparisons significant at the 0.05 level are indicated by ***.

group Comparison	Difference Between Means	Simultaneous 95% Confidence Limits	
Modified - Soil_Cem	0.06500	-0.08325	0.21325
Modified - Calcium_	0.07292	-0.08721	0.23304
Modified - Standard	0.07792	-0.08221	0.23804
Modified - Asphalt_	0.10125	-0.04700	0.24950
Soil_Cem - Modified	-0.06500	-0.21325	0.08325
Soil_Cem - Calcium_	0.00792	-0.15221	0.16804
Soil_Cem - Standard	0.01292	-0.14721	0.17304
Soil_Cem - Asphalt_	0.03625	-0.11200	0.18450
Calcium_ - Modified	-0.07292	-0.23304	0.08721
Calcium_ - Soil_Cem	-0.00792	-0.16804	0.15221
Calcium_ - Standard	0.00500	-0.16618	0.17618
Calcium_ - Asphalt_	0.02833	-0.13179	0.18846
Standard - Modified	-0.07792	-0.23804	0.08221
Standard - Soil_Cem	-0.01292	-0.17304	0.14721
Standard - Calcium_	-0.00500	-0.17618	0.16618
Standard - Asphalt_	0.02333	-0.13679	0.18346
Asphalt_ - Modified	-0.10125	-0.24950	0.04700
Asphalt_ - Soil_Cem	-0.03625	-0.18450	0.11200
Asphalt_ - Calcium_	-0.02833	-0.18846	0.13179
Asphalt_ - Standard	-0.02333	-0.18346	0.13679

APPENDIX C
STATISTICAL ANALYSIS of STRUCTURAL MEASUREMENTS
The SAS System
The GLM Procedure

Class Level Information

Class	Levels	Values
group	5	Asphalt_, Calcium_, Modified, Soil_Cem, Standard

2001 Pavement Deflection Data

Section	Pavement Deflection
Soil_Cement	7.5, 7.4, 6.66, 7.55, 7.79, 7.1, 6.84, 7.43, 7.02, 7.01, 7.06, 6.55
Modified_Subbase	6.43, 6.53, 6.66, 6.57, 6.21, 6.81, 6.36, 6.79, 6.82, 6.44, 6.26, 6.71
Asphalt_Stabilized	6.88, 7.09, 7.02, 6.89, 6.8, 6.82, 6.77, 6.86, 7.1, 6.98, 6.56, 7.06
Calcium_Chloride	6.5, 6.6, 6.5, 6.55, 6.45, 6.63, 6.79, 6.64, 6.63, 6.55, 6.85, 6.42
Standard_Subbase	6.62, 6.67, 6.48, 6.42, 6.3, 6.8, 6.73, 6.7, 6.68, 6.71, 6.29, 6.75
Number of observations	60

Tukey's Studentized Range (HSD) Test for TESTs

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	55
Error Mean Square	0.052268
Critical Value of Studentized Range	3.98855
Minimum Significant Difference	0.2632

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	group
A	7.15917	12	Soil_Cem
A			
A	6.90250	12	Asphalt_
B	6.59583	12	Standard
B			
B	6.59250	12	Calcium_
B			
B	6.54917	12	Modified